Topic: CHEMISTRY. Part I (H)
Expt. No.

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Critical temperature, Critical Pressure, and Critical Volume

Critical temperature :→

It is defined as the temp^r. above which the gas cannot be liquify. It is denoted by T_c

Critical Pressure :→

The minimum Pressure required to liquify the gas at the critical temperature is known as critical Pressure. It is denoted by P_c.

Critical volume :→

The volume occupied by one mole of the gas at the critical temperature and critical Pressure is called critical volume. It is denoted by V_c. The critical temperature, critical Pressure and critical volumes of a gas are ~~collectivity~~ collectively called as critical constant

Relation between critical constant and Vander waal's constant

From Vander waal's equation we know that

$$\left(P+\frac{a}{V^2}\right)(V-b) = RT.$$

$$PV - Pb + \frac{a}{V} - \frac{ab}{V^2} = RT \quad \text{--- (1)}$$

on multiplying by V^2 and devided by P in equation (1) we get

Teacher's Signature :

$$V^3 - bV^2 + \frac{aV}{P} - \frac{ab}{P} = \frac{RTV^2}{P}$$

If $T = T_c$ and $P = P_c$ then:

$$\text{or } V^3 - bV^2 - \frac{RT_cV^2}{P_c} + \frac{aV}{P_c} - \frac{ab}{P_c} = 0$$

$$V^3 - V^2\left(b + \frac{RT_c}{P_c}\right) + \frac{aV}{P_c} - \frac{ab}{P_c} = 0 \quad \text{— (II)}$$

If $V = V_c$ the $(V - V_c) = 0$ or $(V - V_c)^3 = 0$

$$V^3 - V_c^3 - 3VV_c(V - V_c) = 0$$

$$V^3 - V_c^3 - 3V_cV^2 - 3V_c^2V = 0 \quad \text{— (III)}$$

comparing equation (II) and (III)

$$3V_c = b + \frac{RT_c}{P_c} \quad \text{— (iv)}$$

$$3V_c^2 = \frac{a}{P_c} \quad \text{— (V)}$$

$$V_c^3 = \frac{ab}{P_c} \quad \text{— (VI)}$$

On deviding equation (VI) in equ^n (V)

$$\frac{V_c^3}{3V_c^2} = \frac{ab}{P_c} \Big/ \frac{a}{P_c}$$

So $\boxed{V_c = 3b}$ — (VI)

From equation (V) ~~and~~ (VII) Putting this value in equ^n (V)

$$3(3b)^2 = \frac{a}{P_c}$$

$$3 \times 9b^2 = \frac{a}{P_c}$$

$$27b^2 = \frac{a}{P_c} \quad \therefore \boxed{P_c = \frac{a}{27b^2}}$$

Put the value of V_c and P_c in equation (IV)

$$3 \times 3b = b + \frac{RT}{a/27b^2}$$

$$9b = b + \frac{RT_c \times 27b^2}{a}$$

$$8b = \frac{RT_c \times 27b^2}{a} \quad \therefore \boxed{T_c = \frac{8a}{27Rb}}$$